REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
15-10-2007	Final	

4. TITLE AND SUBTITLE
Test Operations Procedure (TOP)
1-1-015 Human Systems Integration

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHORS

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER
TOP 1-1-015

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
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10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
Same as item 8

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES
Defense Technical Information Center (DTIC), AD No.:

14. ABSTRACT
This TOP will provide a capstone overview of HSI testing. It will provide the background for other HSI related TOPs.

15. SUBJECT TERMS

Human Systems Integration	Human Factors	Human Factors Engineering
Systems Safety	Personnel	Manpower
Training	Health Hazards	Soldier Survivability

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**B. ABSTRACT**	**C. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
Unclassified	Unclassified	Unclassified	SAR	37	

US ARMY DEVELOPMENTAL TEST COMMAND
TEST OPERATIONS PROCEDURE

Test Operations Procedure 1-1-015 15 October 2007

HUMAN SYSTEMS INTEGRATION

1. SCOPE AND USE OF TOP 1-1-015.

1.1 Scope. This Test Operations Procedure (TOP) provides guidance for conducting MANPRINT domain test and analysis of all types of materiel and systems tested by the Developmental Test Command (DTC). Several other MANPRINT-related TOPs are cited in this TOP. The material presented in those TOPs augment the information presented here and points the reader to other documents for further guidance.

TOP 1-1-015 provides test procedures, appropriate references, and general guidance for conducting developmental tests across the seven MANPRINT domains. Domains include Manpower, Personnel, Training, Human Factors Engineering, System Safety, Health Hazards, and Soldier Survivability.

This TOP also provides test procedure frameworks for domain-specific testing. The scope of MANPRINT tests during the developmental test phases is specified in DTC PAM 73-1[1*]. The scope of MANPRINT testing during customer tests will be limited to that specified by the customer.

The material contained in this TOP does not include detailed methods for statistical analysis of data. Guidance for statistical treatment of data is contained in standard sources such as National Institutes of Standards and Technology's E-Handbook of Statistical Methods[2] (located at http://www.itl.nist.gov/div898/handbook/) and Electronic Textbook: StatSoft[3] (located at http://www.statsoft.com/textbook/stathome.html).

1.2 MANpower and PeRsonnel INTegration (MANPRINT) and Human Systems Integration (HSI) Overview. HSI is a Department of Defense (DoD) effort designed to optimize the human part of the total system equation by integrating all of its elements into the system acquisition process. HSI is a central theme for system development throughout DoD directives, instructions, and acquisition guidebooks, and provides a common terminology which fosters the implementation of joint Test and Evaluation (T&E). It also addresses the need for human-centered engineering throughout system design, development, and operation. HSI implementation is essential for maximizing total system performance and reducing total lifecycle costs.

Analogous to HSI is the MANPRINT program. MANPRINT is the Army's process to fulfill DoD HSI directives and includes seven domains which are generally comparable to HSI elements. The Army's MANPRINT Program is the implementation of DOD's HSI elements. The term reflects current Army Regulation 602-2[4] (Manpower and Personnel Integration in the System Acquisition Process) terminology. This regulation also specifies agencies responsible for MANPRINT and MANPRINT domain assessments conducted at major acquisition program milestone decisions.

As with HSI the MANPRINT program ensures that Soldier and unit needs are considered throughout the system acquisition process and life cycle. For clarity in this document, the term HSI is understood to encompass both HSI elements and MANPRINT domains.

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[*] Superscript numbers correspond to those in Appendix C, References

Human Systems Integration (HSI) consists of the following eight elements:

1.2.1 Manpower.

Manpower factors are those job tasks, operation/maintenance rates, associated workload, and operational conditions (e.g., risk of hostile fire) that are used to determine the number and mix of military and DoD civilian manpower and contract support necessary to operate, maintain, support, and provide training for the system.

1.2.2 Personnel.

Personnel factors are those human aptitudes (i.e., cognitive, physical, and sensory capabilities), knowledge, skills, abilities, and experience levels that are needed to properly perform job tasks. Personnel factors are used to develop the military occupational specialties (or equivalent DoD Component personnel system classifications) and civilian job series of system operators, maintainers, trainers, and support personnel.

1.2.3 Training.

Training is defined as the learning process by which personnel individually or collectively acquires or enhances predetermined job-relevant knowledge, skills, and abilities by developing their cognitive, physical, sensory, and team dynamic abilities. The "training/instructional system" integrates training concepts and strategies and elements of logistic support to satisfy personnel performance levels required to operate, maintain, and support the systems.

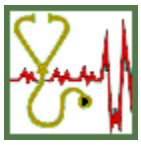
1.2.4 Human Factors Engineering.

Human factors are the end-user cognitive, physical, sensory, and team dynamic abilities required to perform system operational, maintenance, and support job tasks. The human factors engineering community integrates the human characteristics of the user population into the system definition, design, development, and evaluation processes to optimize human-machine performance for both operation and maintenance of the system.

1.2.5 Systems Safety.

Systems safety factors consist of those system design characteristics that serve to minimize the potential for mishaps causing death or injury to operators and maintainers or threaten the survival and/or operation of the system. Prevalent issues include factors that threaten the safe operation and/or survival of the platform; walking and working surfaces including work at heights; pressure extremes; and control of hazardous energy releases such as mechanical, electrical, fluids under pressure, ionizing or non-ionizing radiation, fire, and explosions.

1.2.6 Health Hazards.



Health hazard factors are those system design features that serve to minimize the risk of injury, acute or chronic illness, or disability; and/or reduce job performance of personnel who operate, maintain, or support the system. The design features can include the operating characteristics of a system that create significant risks of bodily injury or death; prominent sources of health hazards include: acoustics energy, chemical substances, biological substances, temperature extremes, radiation energy, oxygen deficiency, shock (not electrical), trauma, and vibration.

1.2.7 Soldier Survivability.

Personnel survivability factors consist of those system design features that reduce the risk of fratricide, detection, and the probability of being attacked; and that enable the crew to withstand man-made hostile environments without aborting the mission or suffering acute chronic illness, disability, or death.

1.2.8 Habitability.

Habitability factors are those living and working conditions that are necessary to sustain the morale, safety, health, and comfort of the user population. They directly contribute to personnel effectiveness and mission accomplishment, and often preclude recruitment and retention problems. Examples include: lighting, space, ventilation, and sanitation; noise and temperature control (i.e., heating and air conditioning); religious, medical, and food services availability; and berthing, bathing, and personal hygiene.

1.3 Using TOP 1-1-015. This TOP provides testers guidance in the development of test plans and execution of MANPRINT-related tests. It is not intended to be used as a stand alone document which fully addresses MANPRINT domains. Instead, it provides a general test procedural framework which needs to be supplemented using domain-specific TOPs and other appropriate guidance.

1.4 Applicable Documents. There are several regulations/instructions/pamphlets that reference HSI test and test-related activities. These documents are helpful in understanding testing requirements, responsible agencies, and reporting authorities. The key HSI-related documents are listed below:

1.4.1 DoD Instruction 5000.2 (12 MAY 03)[5]: Operation of the Defense Acquisition System. This establishes a simplified and flexible management framework for translating mission needs and technology opportunities, based on approved mission needs and requirements, into stable, affordable, and well-managed acquisition programs that include weapon systems and automated information systems (AISs).

1.4.2 Defense Acquisition Guidebook[6] (16 DEC 04): Chapter 6, Human Systems Integration. This Guidebook addresses the human systems elements of the systems engineering process. It will help the program manager design and develop systems that effectively and affordably integrate with human capabilities and limitations; and it makes the program manager aware of the staff resources available to assist in this endeavor.

1.4.3 MIL Handbook 759C[7] (31 JUL 95): Handbook for Human Engineering Design Guidelines. This handbook provides basic guidelines and data on human engineering (HE) design for military systems, equipment, and facilities. This handbook has been designed to supplement MIL-STD-1472F[8].

1.4.4 MIL Standard 1472F[9] (23 AUG 99): Human Engineering. This standard establishes general human engineering (HE) criteria for design and development of military systems, equipment and facilities. Its purpose is to present human engineering design criteria, principles and practices to be applied in the design of systems, equipment and facilities so as to 1) achieve required performance by operator, control and maintenance personnel, 2) minimize skill and personnel requirements and training time, 3) achieve required reliability of personnel-equipment combinations, and 4) foster design standardization within and among systems.

1.4.5 MIL Standard 1474D[10] (12 FEB 97): Noise Limits. This standard establishes acoustical noise limits and prescribes testing requirements and measurement techniques for determining conformance to the noise limits specified in this standard. It is also intended to address noise levels emitted during the full range of typical operational conditions.

1.4.6 MIL Handbook 46855A[11] (17 MAY 99): Human Engineering Program Process and Procedures. This handbook provides Human Engineering (HE) program task guidance, describes the significance of the analysis, design, and test aspects of the HE program, outlines procedures found effective in implementing such guidance, and provides summaries of methods.

1.4.7 Army Regulation (AR) 40-10[12] (01 OCT 91): Health Hazard Assessment Program in Support of the Army Material Acquisition Decision Process. This prescribes specific responsibilities of developers for Health Hazard Assessments (HHAs) in support of Army Acquisition. Describes HHA as a cradle-to-grave integrated effort

1.4.8 AR 70-8[13] (31 JUL 90): Soldier-Oriented Research and Development in Personnel and Training (SORD-PT). This establishes the SORD-PT program, the goal of which is to provide the technological edge necessary to ensure that the Army can recruit and maintain a total force, trained and ready to carry out its assigned roles anywhere in the world, anytime. Essentially, this covers the training aspects of MANPRINT.

1.4.9 AR 70-25[14] (25 JAN 90): Use of Volunteers as Subjects of Research. This regulation prescribes Army policy on the conduct and management of human subjects in testing, including; command responsibilities, review process requirements, approval authorities, and reporting requirements.

1.4.10 AR 70-75[15] (02 MAY 05): Survivability of Army Personnel and Materiel. This regulation implements survivability as outlined in Department of Defense Instruction (DODI) 5000.2 and the Interim Defense Acquisition Guidebook (Formerly the DoD 5000.2-R) [16] within the Army. It prescribes combat survivability policies, responsibilities, and procedures for the sustainment of operational effectiveness and warfighting capability through the life cycle of survivable systems, personnel, equipment, and support. Combat survivability is the capability of a system to avoid (susceptibility) or withstand (vulnerability) man-made hostile environments. The term "survivability" includes both Soldier and equipment unless otherwise specified.

1.4.11 AR 73-1[17] (01 AUG 06): Test and Evaluation Policy. This regulation implements the policies and procedures contained in Department of Defense Directive (DODD) 3200.11[18], DODD 5000.1[19], DODI 5000.2, and the Defense Acquisition Guidebook and specifically prescribes implementing policies for the Army's testing and evaluation program.

1.4.12 AR 350-1[20] (09 MAY 03): Army Training and Leader Development. This regulation is a consolidation of several regulations that provide policy and guidance concerning Army training and education. This regulation updates policies, objectives, and programs; aligns doctrine for the management of Army training and education programs in support of a force-projection Army; defines responsibilities of commanders to conduct and manage Army training and education; and provides new guidance concerning the Army School System, Army modernization training, and selected warfighter, civilian, and leader training and education programs.

1.4.13 AR 385-10[21] (29 FEB 00): The Army Safety Program. This prescribes the Department of the Army (DA) policy, responsibilities, and procedures to protect and preserve Army personnel and property against accidental loss. It provides for public safety incident to Army operations and activities, and safe and healthful workplaces, procedures, and equipment. This regulation assures statutory and regulatory compliance.

1.4.14 AR 385-16[22] (02 NOV 01): Systems Safety Engineering and Management. This regulation implements the DODI 5000.36[23]. It updates Army system safety engineering and management policy and reflects realignment of Army Staff safety responsibilities, reorganization of the research, development, and acquisition process, risk management procedures, and updates terminology.

1.4.15 AR 570-5[24] (30 JUN 89): Manpower Staffing Standards System. This prescribes the detailed policies and procedures for the development of manpower staffing standards. The regulation provides valuable orientation and guidance for those whose responsibilities require their participation in the development of manpower staffing standards.

1.4.16 AR 602-1[25] (08 Feb 91): Soldier Materiel Systems, Human Factors Engineering Program. This establishes policies, procedures, requirements, and assigns responsibilities for Human Factors Engineering (HFE) in the Department of the Army. It emphasizes front-end planning and Soldier performance database development.

1.4.17 AR 602-2[26] (01 JUN 01): Manpower and Personnel Integration (MANPRINT) in The System Acquisition Process. This describes MANPRINT and emphasizes front-end planning of soldier-system design for optimum total system performance as Army Acquisition Policy. It also explains the role of the support agencies to the MANPRINT office. These support agencies conduct the testing and reporting of MANPRINT domain items.

1.4.18 AR 700-127[27] (19 DEC 05): Integrated Logistics Support. This prescribes Department of the Army policies and assigns responsibilities for the management of life-cycle logistics as authorized by DODD 5000.1 and DODI 5000.2. Integrated logistics support (ILS) is the process used by the Army to implement these mandatory life-cycle logistics policies and procedures and includes all elements of planning, developing, acquiring, and supporting Army materiel throughout its life cycle.

1.4.19 Department of the Army Pamphlet 73-1[28] (30 MAY 03): Test and Evaluation in Support of Systems Acquisition. This provides guidance and procedures to implement test and evaluation (T&E) policy for materiel and information systems with regard to planning, executing, and reporting T&E in support of the acquisition process as promulgated by Army Regulation (AR) 73–1[29]: Test and Evaluation Procedures. Developing and deploying Army systems that are operationally effective, suitable, and survivable represents a significant challenge to all involved in the systems acquisition process.

1.4.20 Army Test Evaluation Command (ATEC) Pamphlet 73-1[30] (07 SEP 04): Test and Evaluation Procedures. This pamphlet provides background information on integrated T&E strategies and provides guidance and suggestions for preparing and formatting planning documentation for tests, evaluations and assessments. This process supports development of System Evaluation Plans (SEP), Event Design Plans (EDP), Detailed Test Plans (DTP), System Evaluation Reports (SER), and System Assessments (SA).

1.4.21 Developmental Test Command (DTC) PAM 73-1 (30 OCT 06): Developmental Test Guide. This pamphlet provides background information on developmental testing strategies and provides guidance and suggestions for preparing and formatting planning documentation for tests, evaluations and assessments. This document describes the DTC MANPRINT testing program in Section 9-12.

1.4.22 DTC PAM 602-1[31] (25 July 75): Questionnaire and Interview Design (Subjective Testing Techniques). It presents techniques for the design and administration of questionnaires and interviews, as well as procedures for treatment of the data.

1.4.23 DTC Test Operating Procedure (TOP) 1-1-059[32] (30 NOV 85): Soldier-Computer Interface. This TOP is intended to be used for the HFE Evaluation of the Soldier-Computer Interface of systems under test. It encompasses procedures for an HFE analysis and walk-through, mission simulation, and interview guide.

1.4.24 DTC TOP 1-1-060[33] (07 APR 86): System Safety Engineering. This TOP provides guidance for identifying and evaluating hazards associated with systems under test. The purpose is to provide uniform requirements and criteria for performing system safety analysis during the course of testing material. (This TOP has been superseded by ITOP 5-1-060[34].)

1.4.25 DTC TOP 1-2-608[35] (17 JUL 81): Sound Level Measurements. This TOP describes procedures for measuring the sound levels of system under test. It covers tests for steady-state noise from military vehicles and general equipment, and impulse noise from weapons systems and explosive ordnance materiel.

1.4.26 DTC TOP 1-2-610[36] (15 MAY 90): Human Factors Engineering. This encompasses the HFE procedures for the testing of design, functional performance and environmental considerations for the major test functions (operability, maintainability, transportability, portability, usability, erectability, and habitability) applicable to the HFE assessment.

1.4.27 DTC TOP 2-2-508[37] (24 NOV 82): Automotive Safety and Health Hazard Evaluation. This TOP provides procedures to identify and evaluate real and potential safety and health hazards that exist in military tracked and wheeled vehicles.

1.4.28 DTC TOP 2-2-808[38] (01 OCT 81): Field Shock and Vibration Test of Vehicles. This TOP provides a method for evaluating shock and vibration characteristics of vehicles during operation over test courses. Describes instrumentation and courses, and provides guidelines for determining points at which three standardized levels of human exposure are reached.

1.4.29 DTC TOP 3-2-503[39] (15 AUG 80): Safety Evaluation of Fire Control Systems – Electrical and Electronic Equipment. This TOP provides procedures for evaluating the safety of electrical and electronic equipment in fire control systems for tank weapons and field and air defense artillery. Checklists are included as a guide for identifying electrical and electronic hazards, mechanical hazards and miscellaneous hazards.

1.4.30 DTC TOP 3-2-504[40] (01 MAR 77): Safety Evaluation of Hand and Shoulder Weapons. This TOP provides procedures for evaluating the safety of hand and shoulder weapons.

1.4.31 DTC TOP 3-2-711[41] (02 DEC 82): Safety Evaluation – Radioactive Components of Materiel. This TOP describes procedures for evaluating the radiological safety of materiel components that emit ionizing radiation. Contents include shock, vibration, and climatic tests and a test to determine whether combined storage will result in radiation or contamination.

1.4.32 DTC TOP 3-2-812[42] (23 FEB 66): Field of Vision - Vehicles. This TOP describes procedures to determine the field of vision for the driver of transport vehicles and for the entire crew of combat vehicles.

1.4.33 DTC TOP 3-2-813[43] (23 MAR 85): Field of Fire. This TOP provides procedures for determining the field of fire for vehicle-mounted primary and secondary armament (e.g., tank guns, armored personnel carriers).

1.4.34 DTC TOP 4-2-502[44] (05 MAY 78): Safety Evaluation of Mines and Demolitions. This TOP provides procedures for evaluating the safety of mines and demolitions. It covers inspections and tests for adequacy of safety features; confirmation of functioning loads; sensitivity to accidental detonation; safety during transportation.

1.4.35 DTC TOP 4-2-503[45] (01 July 70): Safety Evaluation – Close Support Rockets and Missies. This TOP provides guidance for determining whether close support rockets and missiles are safe for testing.

1.4.36 DTC TOP 4-2-504[46] (01 APR 79): Safety Testing of Artillery, Mortar, and Recoilless Rifle Ammunition. This TOP describes safety evaluation test procedures applicable to all ammunition for field and air defense artillery, tank guns, recoilless rifles, and mortars.

1.4.37 DTC TOP 6-2-507[47] (15 JUN 81): Safety and Health Evaluation of Hand – Communication/Electronic Equipment. This TOP provides procedures for evaluating potential hazards during testing. Safety checklists, physical tests, observations, and examinations are presented for use.

1.4.38 DTC TOP 7-3-526[48] (05 FEB 93): External Acoustical Noise Measurements for Aviation Systems. This TOP provides procedures for measuring the external acoustical noise of Army helicopters. It covers test procedures for the measurements of steady-state and impulse noise.

1.4.39 DTC TOP 7-3-529[49] (30 SEP 91): Ingress, Emergency Egress, and Emergency Evacuation Testing of Army Aircraft. This TOP describes procedures for the ingress, emergency egress, and emergency evacuation testing of army aircraft. Also contains guidelines for maximum times allowed for emergency egress and emergency evacuation.

1.4.40 DTC TOP 7-3-530[50] (05 FEB 93): Steady-State Acoustical Noise Measurements in Aviation Systems. This TOP provides procedures for measuring the acoustical noise in Army helicopters. It covers test procedures for the measurements of steady-state acoustical noise at crewstations and in the passenger compartment.

1.4.41 DTC TOP 8-2-111[51] (24 April 98): Nuclear, Biological, and Chemical (NBC) Contamination Survivability, Small Items of Equipment. This TOP provides procedures for facilitating test planning, conducting, and reporting. It is to be used primarily for testing of small items of equipment that are decontaminated by the individual Soldier or by small teams operating portable and hand-held decontaminating devices.

1.4.42 DTC TOP 8-2-553[52] (01 AUG 79): Safety Evaluation – Chemical Biological (CB) Items. This TOP provides procedures for identifying and evaluating hazards associated with CB equipment. In addition, requirements for chemical and biological safe test conduct are outlined.

1.4.43 DTC TOP 10-2-206[53] (23 OCT 84): Body Armor. This TOP provides test methods and techniques for evaluating the technical performance and characteristics of body armor and determining its suitability to be subjected to further testing.

1.4.44 DTC TOP 10-2-506[54] (06 JAN 75): Ballistic Testing of Personnel Armor Materials Armor. This TOP describes methods of evaluating the resistance of the materiel used in personnel armor to penetration by projectile fragments, simulated fragments, and small arms ammunition.

1.4.45 DTC TOP 10-2-508[55] (06 MAY 80): Safety and Health Hazard Evaluation – General Equipment This TOP provides procedures required to determine whether general equipment is free from design, operational or maintenance hazards. Checklists and a hazard analysis format are provided to assist test personnel in the assessment of hazards.

1.4.46 ITOP 5-1-060[34] (10 JUN 05): Identification of Hazards for Operators and Maintainers of Surface Launched Weapons This ITOP is a modified version of DTC TOP 1-1-060, System Safety Engineering, which is listed in paragraph 1.4.24. ITOP 5-1-060 contains a safety checklist entitled CECOM Supplement 1 to AR 385-16. This safety checklist addresses all the provisions of Guideline 1 of MIL-HDBK-454[56].

2. FACILITIES AND INSTRUMENTATION.

Specific requirements for the facilities and instrumentation are included in the specific test procedures of the respective TOPs under this HSI topic.

2.1 Facilities. Facilities needed depend on the classification of the item under test and the required tests. The test conditions may also drive the needed facilities for the test. Facilities normally provided for other subtests are often adequate for the requirements of HSI testing. The HSI tests that are dependent on certain facilities have been described in this TOP (section 3.10).

2.2 Instrumentation. Requirements generated in HSI test plans drive specific types of instrumentation. Choosing the right instrumentation depends on test requirements, instrumentation/facility availability, and funds available. Several examples of instrumentation are described below:

2.2.1 Human Performance Instrumentation. Instrumentation for measuring human performance may include stopwatches (for time task completion), video cameras (for recording task completion), and questionnaires/surveys/After Action Reviews.

Test methodologies adjust, as necessary, to new and emerging technologies. One area of greatest change is in human performance measurement and analysis. For example, tools addressing situational awareness, cognitive and physical workload, and team performance are changing how items are tested and the nature of data collected. Instrumentation to measure these areas is being developed for application to testing.

2.2.2 HFE Instrumentation. Instrumentation covering HFE testing include, for example, items to measure: anthropometry, atmosphere/environment, force/torque/dimension, illumination, and noise. These items are covered in TOP 1-2-610, Human Factors Engineering. Some instrumentation not covered in TOP 1-2-610, include typical models and simulations used in HFE testing, such as Jack and other anthropometry modeling.

2.2.3 Soldier Survivability. Instrumentation used in Soldier survivability testing can include human surrogates (dummies and mannequins). Instrumentation can also be ballistic impact measurement instrumentation and high speed cameras to record impacts.

2.2.4 System Safety and Health Hazards. Instrumentation used in system safety and health hazard assessments is used to collect MANPRINT data to support safety releases, safety

confirmations, and Human Use Committee (HUC) actions. Instrumentation can include toxic gas analyzers and accelerometers (for vibration determination). Instrumentation to measure mechanical, electrical, chemical, fire and explosive hazards can be used. Other instrumentation is used, as required.

2.2.6 Modeling and Simulation. M&S has become increasingly important in testing. Simulations allow testers to conduct multiple runs very quickly at low cost. M&S is used in every domain of HSI testing. Examples of this can be manpower and personnel testing using the Improved Performance Research Integration Tool (IMPRINT) and human performance testing with the Infantry Warrior Simulation (IWARS).

2.2.7 Questionnaires/Surveys. These instruments are normally developed and administered to obtain data from test participants. Questionnaires and surveys can be administered either electronically or on paper. Electronic versions decrease the need to enter answers into databases by hand and eliminate any ambiguity from reading test participant's handwriting. Examples of questionnaires/surveys used can be NASA TLX (workload), Situation Awareness Rating Technique (SART), and fit/comfort (equipment compatibility).

2.2.8 Other Domain-specific Instrumentation. Other types of instrumentation can be used for the domain tests. Instrumentation is not limited to that listed in this TOP.

3. TEST PREPARATION METHOD.

Before using this TOP to plan an HSI test, obtain the following documents for the test items.

a. System Evaluation Plan (SEP)

b. Event Design Plan

c. MANPRINT Management Plan

d. Test and Evaluation Master plan (TEMP)

e. Detailed Test Plan

f. Initial Capabilities Document (ICD) / Capability Development Document (CDD)

g. Safety Documentation & safety releases

h. Technical Manuals

i. Other relevant documents

These documents can be obtained from the following sources:

a. The project evaluator from Army Evaluation Center

b. The Program Manager at the Program Manager's Office.

c. The Test Director at the Test Center

d. The Test Manager at Developmental Test Command

e. The Material Developer

A primary overall emphasis in HSI testing is to measure and analyze the soldier's impact on total system performance and the system's impacts on Soldier performance. Since the Soldier is an integral component of the system, total system performance must be addressed to determine the soldier's effect on the system and visa versa. The major requirements in preparation for an HSI test are to identify the item to be tested, how the test is to be conducted, and what are the evaluation criteria. In determining what is to be tested, the critical issues and objectives must also be determined using the data source matrix attached to the SEP and the TEMP. Past test events and test reports can ascertain prior HSI concerns. Objectives, as well as critical issues, may be designated/described in system evaluation plans or other pertinent information related to the item under test. For some programs, an ARL-HRED MANPRINT POC maybe be assigned to support the program. He/she will be able to assist in obtaining program-related information.

3.1 Step 1 - Classify the Test Item. One of the initial steps in planning an HSI test is to classify the test item into one or more appropriate test item classes. The following are general classes that can be used to group items and determine which types of testing that will be necessary. This type of information may already be found in documentation concerning the item.

a. Vehicles – Air, Ground, Unmanned and Manned

b. Weapons/Ammunition – Individual, Crew Served, or Ammunition

c. Material Handlers – Soldier-Operated or Soldier-Monitored

d. Electronics/Signals – Sensors & Detectors or Information/Command & Control Systems

e. Operational Support – Maintenance & Repair equipment, Material Production & Environmental Control, or Major Construction Items

f. Troop Support – Consumables, Clothing & Personal Equipment, or Living & Working Areas

3.2 Step 2 - Determine Applicable Test Item Functions. Primary areas of concern in an HSI test are listed below:

a. Operation of the item in representative environments

b. Maintenance of the item

c. Erectability of the Structure

d. Portability/usability/habitability of the item

e. Habitability of the living conditions within the item

f. Personnel Survivability of the item

The test functions become important as test plans are written. The test item functions describe the operational environment the test will be conducted in and which procedures will be examined during the test. The documentation (mainly ICD/CDD) will list capabilities and requirements of the item under test. The System Evaluation Plan provides an additional source for determining which functions should be examined for testing.

3.3 Step 3 - Identify General Test Conditions. Use conditions are test user, facilities/instrumentation, environment, and operational variables that must be controlled within the test. These use conditions can affect operability, maintainability, as well as the other test functions. By controlling the use conditions within the context of test events, the variability (or biases) of the item performance data can be decreased.

The HSI specialist planning the test will ensure that the HSI-related tests are performed under use conditions representing real world conditions to the degree feasible. These use conditions can affect performance during any of the test item functions.

TOPs, (such as: TOP 1-1-003[57] Arctic Personnel Effects, and TOP 1-1-006[58] Desert Environment Considerations) prescribe specific use conditions for certain type of tests. The following sections outline five categories of use conditions applicable to HSI testing.

3.3.1 User (Test Participant) Conditions. Use conditions associated with the test participant (or intended item user) include the individual differences between the test participants and the intended user population. These individual differences can affect performance in each of the test item functions and can be identified, characterized, and collected during testing through anthropometric measurements and demographic surveys. The following is a list of several areas of individual test participant differences generally addressed during testing. Other items can be addressed based on program requirements.

a. Gender (male, female)

b. Anthropometrics (height, weight, limb length, reach distance, sitting height, etc.)

c. Clothing worn (size, type)

d. Personnel encumbrances (combat pack, weapon, radio, etc.)

e. Skills and knowledge (MOS, experience, training, situational awareness, decision-making ability, etc.)

f. Special considerations (handedness, physical strength, eye correction, facility of English language, etc.)

3.3.2 Team Dynamics Conditions. As distributed testing capabilities increase, measurement and analysis of team performance becomes increasingly important. How well a team performs is a function of the team dynamics. By identifying team characteristics and controlling for them, team characteristics can be used in data analysis to decrease human variability within and between groups. The following is a list of some of the team characteristics that should be identified and measured.

a. Unit Cohesion

b. Shared Situational Awareness

c. Leadership

d. Decision-making abilities (presence of decision-making aids)

3.3.3 Facilities/Instrumentation Conditions. As distributed testing increases, documentation of facilities and instrumentation becomes important in test planning and reporting. Using one facility and instrumentation set over another may produce inconsistent data across test centers or tests based on the facility/instrumentation. For example consider one Military Operations in Urban Terrain (MOUT) site over another. One might use realistic buildings, furniture/debris, and civilians in the scenes, while the second might use a plywood shoot house without obstacles. Both will give different performance times and achieve different results which need to be addressed in data reduction and analysis.

3.3.4 Environmental Conditions. Use conditions associated with the environment include climate, weather, and work conditions under which the item will be operated and the factors associated with the intended mission which affects the operability/maintainability of the test item. Listed below are several environmental conditions that could affect performance.

a. Precipitation (rain, snow, fog and similar meteorological conditions which affect visibility and mobility)

b. Temperature (extremes of heat and cold)

c. Humidity (extremes – assessed in conjunction with temperature)

d. Wind (effects on mobility, handling of components)

e. Terrain (type, evenness, hardness, effects on mobility or footing)

f. Ventilation (effects on comfort, safety and performance)

g. Airborne contaminants (dust, noxious fumes)

h. Lighting (type, location, levels – effects on visibility)

i. Noise (spectrum, loudness, effects on comfort, safety, reception of communication, performance)

j. Vibration (spectrum and intensity, effects on comfort, safety and performance)

HSI test planners need to examine the use environment for the item under test. If the test item is a computer workstation in a command and control vehicle, there is a different environmental condition than if it is aboard a ship or at a stationary command headquarters.

3.3.5 Operational Conditions. Operational use conditions include characteristics of the deployment and mission which could affect operability/maintainability of the test item. These conditions must be identified to ensure that the test has operational realism. They will be tailored to the Program Requirements as identified in such documentation as the ICD/CDD and/or TEMP. These conditions include:

a. Threat characteristics (type, number, distance, deployment)

b. Force characteristics (mission profile, operational mode summary, crew composition)

c. Conditions of readiness

d. Blackout conditions

e. Logistical constraints

f. Emergency conditions

3.4 Step 4 - Identify/Analyze Operator/Maintainer Tasks. One of the primary objectives of developmental testing is to verify that design characteristics of the test item are or are not adequate to support the intended use of the item. The intended use is best specified by a set of tasks which operators and maintainers perform. Once a set of tasks has been defined for the applicable test functions, task checklists are created, by systemically going through the tasks on the checklist.

3.4.1 Task Identification and Analysis. Identification of tasks to be analyzed begins with a review of test item documentation. Additional information can be gathered from;

a. Contractor Task Analyses – collected from the PM

b. Generic Soldier/Item Tasks – extracted from the Soldier's Manual of Common Tasks

c. Legacy Item task lists – collected from old test reports and evaluations

d. Test Item Operating Manuals and Maintenance Manuals – collected from the PM

e. Operator/Maintainer Experience – gathered from SMEs

3.4.2 Tailored Task Checklists. After the criticality analysis and the task sequence is determined, a specific Task Checklist can be created appropriate for the item. The Task

Checklist must be completed at this point in the planning process so that it can be used to identify potential problems and areas where further investigation will be required during HSI testing.

3.5 Step 5 - Preliminary HSI Analysis. The MANPRINT specialist or test planner will use any or all available information, including the technical data package, manuals and the item itself, if it is available, to conduct the preliminary HSI analysis.

3.5.1 Prepare Preliminary Analysis. The identified tasks from the task checklists should receive extra attention during the HSI test. For each task identified, factors that affect completion of the task should be considered. The factors will be the items during the HSI test that should be studied. Factors can be;

a. Environmental conditions (e.g., effects of ambient noise on a communication task, or effects of illumination on an inspection task)

b. Equipment characteristics (e.g., size, shape, location, visibility, etc., of components)

c. Test participants' characteristics (e.g., limb length, clothing conditions, training, MOS, group dynamics, and experience with similar items)

d. Performance (weapon delivery, tracking, road following, decision-making, etc.)

3.5.2 Walk-through and Talk-through. This form of preliminary analysis should be conducted if sufficient information exists for the operator/maintainer tasks. It can also be performed if the item is available for analysis. An experienced operator/maintainer can assist the HSI specialist in the preliminary analysis. The analysis consists of considering each task in sufficient detail to identify:

a. Potential HSI problems in: equipment design characteristics (including system safety, health hazards, personnel survivability, ergonomics), environmental effects, and system performance

b. Test participant characteristics (body dimensions, skills, physical condition, decision-making, situational awareness, state of alertness, stress, clothing) to be evaluated

c. Types of HSI tests to be included and measurements required

d. General data requirements

e. Facilities and instrumentation required

3.5.3 Modeling & Simulations. This form of testing (if available) should be conducted, as appropriate. Modeling & Simulation (M&S) can take many forms from physical mockups to 3 Dimensional renderings of the item. If the item is not immediately available for preliminary analysis, then a model can be used to approximate the final layout and placement of the details

on the item. Simulations can be used to analyze the human's interaction with the item. Human figure models can be run in simulation with item models to analyze interactions. M&S tools can be used in all domains of HSI testing as they can supplement demonstrations for the same purposes.

3.5.4 Documentation Review. Another type of preliminary analysis can be completed by conducting a system document review. By examining the current program documents, legacy system's documents and lessons learned the tester may be able to determine which aspects of the item need to be studied to determine the overall system performance.

3.6 Step 6 - Identify Data Elements. At this point in the test planning process, the determination of which data elements to be collected must be made. By identifying the individual data elements to be collected, the test procedures to collect those data elements can be prescribed.

3.6.1 Determine the Data Requirements. Review of the system documentation, especially the system evaluation planning documents is required at this stage. By reviewing the data requirements, the data elements that need to be collected can be gathered. Data requirements can also be contained within the ICD/CDD, TEMP and the SEP.

3.6.2 Determine the Applicable Test Item Components. The HSI test shall include procedures for the test and analysis of the HSI design, technical and performance characteristics of the system. To determine the specific characteristics applicable to the system being tested, the HSI specialist must identify the Test Item Components with which the operator/maintainer interacts in performing the specified tasks.

3.6.3 Determine Data Element and Item Function Pairing. The applicable item functions, identified in Section 3.2, are used with the required data elements to determine test procedures. The data elements that need to be collected must be matched with applicable test functions to make sure all data elements will be collected with the test procedures created during the next section. That is usually part of the Detailed Test Plan process.

3.7 Step 7 - Select Test Procedures. The next step in the process is to decide on which test procedures, methods, and/or instrumentation to be used to test and analyze the test item. The following is a list of various types of procedures that can be used for an HSI test:

3.7.1 Equipment, Technical, & Design Characteristics. Technical characteristics include the mechanical, thermal, atmospheric or illumination environments created by the equipment during use, and the environmental conditions under which the equipment must be operated and maintained (weather, climate, temperature, noise, terrain, illumination, etc.). Technical characteristics to be measured can be determined from equipment documentation. They will be assessed using specific test procedures extracted from other HSI-related TOPs.

Design characteristics include the physical dimensions of the equipment components which are used by or which contact the equipment operator/maintainer. Design can also include the displays for a piece of equipment; as well as the software and how that is displayed to the user. Design characteristics are assessed using specific Test Procedures from other HSI TOPs.

Various checklists have been designed to help testers obtain data. A checklist contains test relevant items that must be systematically addressed. While checking off an item, the tester might have to perform an action to complete that item. For example, if the item assesses vehicle entry/egress, the tester may have to measure the size of the opening, the force needed to open the door, and handhold and footrest accommodation inside and outside the vehicle. Several measurements may be required before checking a single item on a checklist. Several types of checklists are explained below.

3.7.1.1 Equipment, Technical & Design Checklists. These checklists can be made for assessing any type of equipment. Several different types of checklists are explained below:

a. Human Factors Engineering/Design checklists – These checklists focus on design requirements and specifications for that piece of equipment. HFE design requirements are included in MIL STD 1472F and noise requirements are included in MIL STD 1474[59]. Several other MIL STDs and the equipment's documentation will specify which requirements need to be accessed and measured. These should be consulted before any testing begins.

b. Environment checklists include many of the same design requirements from HFE checklists. These items include noise, lighting, air pressure, and hazards caused by the equipment while it is operating. Examples can be the interior lighting inside a vehicle, noise inside a helicopter or maintenance hazards for engine repair.

c. Workspace accommodations checklist assess the immediate environment surrounding the user. Items can include workstation ergonomics, toxic fumes, head clearance, and sufficient heating and cooling for occupants.

3.7.1.2 Safety Review. This type of checklist deals with items that may affect the safety of the Soldier while he/she operates/maintains the piece of equipment. Items to examine include mechanical hazards, electrical hazards, and personnel safeguards. (e.g. sufficient lighting to work, system shutdowns and lockout procedures for maintainers, and a habitable work environment for occupants)

3.7.1.3 Health Hazard Checklist. This type of checklist deals with items that may affect the long-term safety/well being as well as short-term performance of the operator/maintainer. Items can include toxic fumes, excessive vibration, temperature extremes, and radiation levels. Specific industrial hygiene measurements should be made to verify suspected hazards.

3.7.1.4 Survivability Checklist. This type of checklist deals with items that directly affect the survivability of the Soldier during operation. Items such as ballistic protection, decreasing fratricide, and maintaining air pressure all affect the survivability of the Soldier during operation of a piece of equipment.

3.7.2 System Performance. The evaluation of human integration as part of the total system performance is important. How the user interacts with the equipment can impact greatly on the performance of the total system. While the user affects the performance of the equipment, the equipment affects the performance of the user. This symbiotic relationship is difficult to

measure but essential for measuring total system performance. Performance of the user can be measured at three different levels: individual, team/crew, and distributed.

a. Individual performance deals with measures concerning the individual operator/maintainer. Items such as individual task completion time, individual situational awareness, cognitive workload and error rate can be collected concerning only one individual. These measures all impact the individual performance as it pertains to mission success.

b. Team/crew performance measures concentrate on team aspects such as team Situational Awareness (SA), mission completion time and team cognitive overload. These measures are harder to collect as well as harder to evaluate. Sometimes it is hard to determine if mission failure was due to the equipment or to team dynamics/characteristics.

c. Distributed performance measures are the hardest to measure. During these types of measurements, team members work together toward a goal but they are not co-located. Items such as message send/retrieval rate, dropped messages, and mission completion time all can be measured distributively.

3.8 Step 8 - Develop Questionnaires, Interviews, Surveys, and Data Collection tools. Valid and reliable data reflecting personnel opinions and insights concerning Soldier-equipment system performance capability, military utility, and Soldier acceptance shall be obtained through the use of carefully prepared and administered questionnaires and interviews. These methods are employed to obtain opinions, attitudes and preferences of personnel who have "hands-on" experience with the equipment.

Questionnaires, interviews, and surveys can serve as additional data collection tools. They can collect data on variables, such as workload and SA, where only partial instrumentation measurement and analysis capabilities exist. They also serve to supplement and clarify information derived from observations and measurements concerning identification of use problems, magnitude of problems, causal factors, and test participant perceptions of implications and effects of such problems. One place to find guidance in the preparation of questionnaires, interviews and surveys is provided in DTC PAM 602-1.

3.9 Step 9 - Identify Test Participants. When performing operational tasks, test participants need to be representative of the user population in terms of MOS, skill level, and training. Test project personnel therefore, shall review the item documentation to determine the following characteristics of the intended user population. In addition, any specific training programs necessary to operate, maintain, or otherwise use the item must be identified. The treatment of the test participants should follow AR 70-25: Use of Volunteers as Subjects of Research procedures.

The names of test participants will not be used in test reports, so each participant should be identified by a random code. This code needs to be consistent between the various HSI procedures and data forms (i.e. questionnaire/ interview responses and comments, demographics,

anthropometry, tasks checklists, speech intelligibility, etc.). The code should be randomly assigned and should be consistent with the participant's code on previous tests.

If Soldier operator, maintainer, test and evaluation (SOMTE) personnel are used as test participants, consult DTC REG 73-6[58] for proper use.

The information listed below represents sample criteria for subject selection. The sample size for the test is based on the required confidence interval and can be found using DTC TOP 3-1-002[59] (25 JAN 67): Confidence Interval and Sample Size. The distribution of each characteristic among the test participants shall be similar to that of the target population within selection constraints. The characteristics to be determined and recorded for all participants shall include consideration of the following:

a. Gender – The representation of males and females in the test sample should be similar to that of the intended user population.

b. Physical Dimensions – The ranges of heights and weight shall be specified, giving due consideration to the range of these dimensions expected of typical user personnel when the system is fielded. Specifically, the range should encompass the 5th through 95th percentile in pertinent dimensions.

   Since the percentile values are not additive between different dimensions, there is not a typical 5^{th} or 95^{th} percentile Soldier. For example, it is incorrect to assume that the combination of the 5th percentile values will describe the dimensions of a "5th percentile man."

   Determination must be made of specific body dimensions of importance for item use (reach, seated height, kneeling, etc.). No person with a special duty or limited duty profile can be permitted to participate unless a task analysis reveals that the restriction to his/her activities have no impact on the tasks required in the test.

c. Sensory Acuity – All test participants should have had a recent (within the last 12 months) test of vision and audition. If vision or audition are critical to the test function (or can be impaired during function), the appropriate test shall be given both immediately before and after test operations. Minimum standards should be stated for each of these sensory modalities depending upon an analysis of the requirements of the tasks to be performed. The inclusion of participants who wear glasses should be considered if appropriate to the particular test.

d. MOS - The required MOS will normally be specified in the MANPRINT Management Plan, Target Audience Description, and potentially in the SEP, DTP, or other test directive. If it is not, a determination must be made of the MOS and whether the specified MOS must be the test participant's primary MOS or whether a Soldier with this specialty in a MOS is acceptable. Alternate specialties may be acceptable substitutes.

e. Grade – Test participants should represent the grades and skill levels specified for test item users or as specified in the ICD/CDD.

f. Item Specific Training – If training is required for use of the test item, this training shall be provided to test participants prior to data collection.

3.10 Step 10 - Identify Test Facility/Instrumentation Requirements. Facilities need to be properly equipped and instrumentation needs to be calibrated to standards, as required. Identification of facilities/instrumentation is dependent on the test procedures being used and the availability of test assets. Specific test procedures, explained in individual TOPs, will prescribe facility/instrumentation requirements. Facility/instrumentation requirements may be found or implied in evaluation planning documents.

3.11 Step 11 - Identify Test Controls. Test controls to be implemented in a given HSI-related test must be appropriate for that test. Every test control is not needed for every test but is required when appropriate. It is important to control difference between test events to minimize the impact on data variability. If the differences are properly controlled, the identified variability (or biases) among test conditions will be due to only the test item.

3.11.1 Control of Test Participants. Selection of personnel to serve as operators and maintainers should be based on the characteristics explained in step 9. The selection should be a representative sample of the target user population. This should minimize the cumulative effect of experience, motivation and skill sets on test execution.

3.11.2 Control of Test Facilities/Instrumentation. In addition, the test facilities/instrumentation in use for a test should remain constant during each of the test events. If the facilities/instrumentation are changed during a test this will increase data variability.

3.11.3 Control of Test Procedures. The use of consistent procedures among test events is necessary to decrease the data variability across the test conditions. To accomplish consistency operators and maintainers are to perform according to standard procedures as indicated in the appropriate technical manuals or operator and maintenance instructions accompanying the test item. This ensures more valid inferences from test results with regard to representative participants.

Not only must the test participants follow standard procedures, test personnel and administrators must follow standard procedures. Not only does this decrease the data variability between test events, it allows for repeatability of data for future follow-up test events.

3.11.4 Control for Comparison of Competitive Systems. When comparing competitive items, personnel operating the competitive items should have comparable training (i.e., personnel should be cross-trained on the items being compared). To minimize the effects of variability (Soldier and equipment) due to performing over a period of time, whenever possible, conduct the comparison tests in the same time frame under the same environmental conditions. To further minimize the influence of such sources of variability, if possible, repeat the test procedure switching the person (or crew) from Item A to Item B as discussed in section 3.11.5 below.

3.11.5 Control of Assignment of Test Participants to Test Conditions. When creating test procedures, the tester may have to perform several tests where different environments or item configurations are required. For example, a universal workstation may have to be tested in a

static, mobile, and shipboard configuration. Ideally a large group of test participants should be randomly assigned to the various test conditions. This will allow each participant to be involved in only one event. This would eliminate practice and order effects for the different test conditions.

If test participants are used in every test condition individual differences will not affect the data, because their individual differences will be the same across all of the test conditions. The term individual differences refer to the fact that on any task certain test participants will perform better than others. This may be due to differences in sensory acuity, strength, memory capacity, experience on similar tasks or whatever. The goal should be to control this source of variability in performance so that it does not bias the test results. Whenever the data for item A arise from one group of test participants and the data for item B arise from another group, apparent differences in performance between items A and B could actually be due to differences in skill between the groups and the test would be biased. So whenever possible, the same group of test participants should be used in each test condition.

There are cases where this approach is not possible, where test participants from one condition are not available for another condition, or inclusion of participants from a previous event would skew the results. For example if a test has only ten targets available for an evaluation of a target detection system, the same test participants cannot be used a second time because they would know where all of the targets are located. If randomizing participants into test conditions is not possible, then split the test participants into groups and use the selection characteristics from step 9 to achieve equivalent (or as equivalent as possible) test participant groups using a matched groups design.

3.11.6 Control of Order of Presentation of Test Conditions. Given that test participants will serve under each test condition, biases might be formed due to the order of presentation. Since each test participant will perform tasks under each test condition, the conditions will have to be presented in some order such as A first, B second and C third. The problem here is that participant's performance will probably improve over the course of the test because of practice as the tasks are repeated. In the case above, if performance under condition C were better than under B and better under B than A, there would be no way to tell if this is due to true differences attributable to the conditions or due to learning on the part of the participants. The solution is to counter-balance the order of presentation by varying this from one participant to another. This can be done by randomly assigning participants to groups where there are as many groups as there are test conditions. If four conditions are to be tested and twenty participants are available then groups of five would be used.

When assigning test participants, it is sometimes suggested that sufficient practice should be given before data collection begins and that performance has improved due to practice as much as it is going to. The learning curve will then be at an asymptotic value or participants will be at the top of the learning curve. Unfortunately, human performance on skilled tasks generally continues to show marginal improvement after months of daily practice and thousands of trials. The preferred approach is to provide as many practice trials as project resources will permit and then use a counter-balanced order of presentation of conditions as shown in FIGURE 3-1.

Some counter-balanced orders of presentation of two, three, four, and five test conditions are shown in FIGURE 3-1. These types of counter-balanced orders of presentation are called Latin squares. For test conditions numbering greater than five, Latin squares can be constructed or they can be found in an experimental design book. If the Latin square is to be constructed each of the test conditions appears once and only once in each row and in each column. If any two rows or any two columns of a Latin square are interchanged, the result is still a Latin square.

Two Test Conditions - A, B			
		Trial Block	
Group	Participants	1	2
1	1-5	A	B
2	6-10	B	A

Three Test Conditions - A, B, C				
		Trial Block		
Group	Participants	1	2	3
1	1-5	A	B	C
2	6-10	B	C	A
3	11-15	C	A	B

Four Test Conditions - A, B, C, D					
		Trial Block			
Group	Participants	1	2	3	4
1	1-5	A	B	C	D
2	6-10	B	C	D	A
3	11-15	C	D	A	B
4	16-20	D	A	B	C

Five Test Conditions - A, B, C, D						
		Trial Block				
Group	Participants	1	2	3	4	5
1	1-5	A	B	C	D	E
2	6-10	B	C	D	E	A
3	11-15	C	D	E	A	B
4	16-20	D	E	A	B	C
5	21-25	E	A	B	C	D

FIGURE 3-1: Recommended Orders of Presentation of Test Conditions

In the two test condition Latin square block of FIGURE 3-1, two test conditions A and B are shown. Ten participants are used in the test and are assigned at random to groups (1-2) and participant numbers (1-10). If a workstation is to be used in a static environment under condition A and in a mobile environment under condition B, then group 1 (participants 1-5) will evaluate the workstation in a static environment first and will then evaluate it in a mobile environment. Group 2 (participants 6-10) will be in the static environment first and then in a mobile environment. Conditions A and B will have received an equal number of trials by each test participant and under each trial block (1 and 2). In principle, individual differences between participants will cancel out and effects of practice which are associated with trial blocks 1 and 2 will cancel out of comparisons between the two conditions.

3.12 Step 12 - Develop Test Plan. The final step before test execution is to construct the test plan and obtain the necessary level of approval. Most HSI testing is a subtest within a much larger test and only requires a test plan to be inserted into a larger Detailed Test Plan. Whether the test plan is a stand-alone document or embedded within a larger detailed test plan, the test plan is still needed to detail the necessary steps in completing the test. It also serves as documentation for the test.

3.12.1 Preparation of the HSI subtest within the Detailed Test Plan. When the HSI test is to be a subtest of a much larger test program, the test plan is to be written as a part of the Detailed Test plan. Section 2.0 of the Detailed Test plan contains the individual subtests and the following three parts of the subtest description. The HSI test plan shall be written in accordance with DTC PAM 73-1. The subtest plan shall follow the following format:

a. Objective: This shall be a concise statement of the objective or issue to be addressed in the subtest, including the subtest's relationship with the overall test objectives.

b. Criteria and Data Analysis: This shall be a statement of the criteria contained in or referenced in the Evaluation Planning Documentation or DTC directive. It will also include a description of the data listed in the data required section that needs to be reduced and analyzed, and how the comparison against the criterion statements will be made. The source of all criteria should be clearly identified down to the paragraph number.

c. Test Procedures and Data Required: This shall detail both the procedures to be used in collecting the data and test specific data to be obtained during the test. The TOP procedure should be referenced along with a brief description of the procedure. If the procedure deviates from a TOP or in the absence of a TOP, the procedure shall be described in detail. This shall specify the accuracy requirements of the data and the numbers of samples or observations.

3.12.2 Preparation of a Stand-alone HSI Test Plan. If the HSI test is to be stand-alone and not part of a much larger test program, then the HSI test plan is to be a self contained detailed test plan. The format stills follows the guidance in DTC PAM 73-1. The following is a brief description of the sections needed for the HSI test plan.

a. Section 1: This part of the test plan includes the system description, summary and unique test personnel requirements sections. Section 1 gives the background for the test as well as any information that is needed to explain the subtests in the next section.

b. Section 2: This section contains the subtest test plan as described above.

c. Appendixes: The appendixes give detail that is needed for conducting the test. The following lists the six appendixes that are contained in a Detailed Test Plan.

i. Test Criteria

ii. Test Schedule

iii. Informal Coordination

iv. References

v. Abbreviations (optional)

vi. Distribution List

3.12.3 Review of Test Plans. Following preparation of the HSI Test Plan, the test-project personnel shall review the plan to ensure that the factors which could reduce the validity and reliability of the results have been eliminated/minimized. In particular, the test conditions, the test design, and the test controls are to be reviewed to determine if the planned test will provide unbiased data. Once the individual test plans are consolidated together into a Detailed Test Plan (DTP), the DTP is provided to the AST and the T&E WIPT for review and comment.

3.12.4 Approval of Test Plan. After the test plan review, the plan must be submitted for approval. After finalization the DTP is approved by the CG, DTC or his designee (usually the test division chief).

If test participants are used in the test, a Human Use Committee (HUC) decision may have to made. AR 70-25 addresses conditions that require a HUC review. If required the DTC Safety office will require an approved DTP and approved safety releases to be used in the HUC review.

If the test is conducted outdoors, addressing the environmental issues may also be required as a part of the approval process.

4. DATA REQUIREMENTS AND ANALYSIS.

4.1 Data Required. Data to be acquired in HSI tests includes the data that are applicable, as appropriate, to all domains and will include data that are specific to the Design and Performance tests.

4.1.1 Data General to All Types of Tests. There are types of data that are common to most or every test.

a. Demographic data on test participants; if test participants are used

b. Descriptions of the test conditions and test controls

c. Description of the test design, run schedule and test conditions for each run

d. Descriptions of facilities/instrumentation/materials (including modifications from non-standard configurations)

4.1.2 Data Specific to Equipment, Technical & Design Characteristics Tests Performed. The Equipment, Technical and Design Characteristics tests have sets of data that are common to

these series of tests. These sets of data are taken from the requirements in the system documentation and are usually collected as checklists are completed. The following is a brief list of the types of data that can be collected.

a. Completed design checklists (e.g., Soldier survivability, health hazard)

b. Environmental parameters (e.g., lighting, noise, temperature, humidity)

c. Workstation evaluation (e.g., speech intelligibility, visibility, HCI evaluation)

4.1.3 Data Specific to Performance Tests Performed. Performance Test data are based on instrumentation readings, test participant feedback as well as HSI specialist observations and analysis. This set of data will help assesses the impact of the Soldier on the machine's performance and visa versa. The following is an abbreviated list of data elements that could be collected.

a. Error Rates and error likelihood estimations

b. Task completion times

c. Situational Awareness (Individual and team) and the workload involved in maintaining SA

d. Workload (cognitive and physical) and the impact on error rate and task performance

e. New equipment training effects

f. Data collected from interviews/surveys/questionnaires

g. Completed task checklists

4.2 <u>Data Reduction, Analysis and Presentation.</u> The data reduction and analysis should follow prescribed procedures from other pertinent TOPs and statistical manuals. The degree to which the test item and its subsystems (maintenance and training packages) conform to HSI specifications, standards and requirements should be presented in narrative form. Instances of nonconformance should be supported by relevant measurements and photographic illustrations.

4.2.1 Data Reduction and Statistical Analysis. The first step in data reduction and analysis is to compile the raw data. If data from several different test sites and/or instrument configurations are used, then data compatibility should have been addressed in the planning stages and resolved here in the data reduction phase. After the summary tables are compiled, the data is ordered and then checked for accuracy. Outliers need to be discussed in the analysis, and if warranted not included in data analysis.

During many tests, multiple measurements are taken of a particular test item characteristic because the measurements are subject to random fluctuation. Appropriate descriptive statistics shall be calculated from the data. Applicable statistics include measures of central tendency

including the mean, median and mode and measures of variability including the standard deviation and inter-quartile range. Frequency distribution analysis includes tabulation of raw frequency data, conversion to proportions or percent values and graphing using bar charts.

Testers may have to perform more advanced data analysis. Advanced statistical techniques such as T-tests, Chi-square, F-test, and analysis of regression may be necessary based on test requirements.

The material contained in this TOP does not include detailed methods for statistical analysis of data. Guidance for statistical treatment of data is contained in standard sources such as National Institutes of Standards and Technology's e-Handbook of Statistical Methods (located at http://www.itl.nist.gov/div898/handbook/) and Electronic Textbook: StatSoft (located at http://www.statsoft.com/textbook/stathome.html).

4.2.2 Design Assessment. All HSI-related quantitative measurement data (e.g., anthropometric, noise, illumination, temperature, etc.) should be presented in tabular or graphic form for direct comparison with the specified criteria and to show the degree of compliance or noncompliance. The results of observation checklists and questionnaires/interviews shall be summarized and presented in tabular form. When an adequate sample size is available, the results should be submitted to statistical analyses.

4.2.3 Performance Assessment. The data should also be analyzed to find the cause of any degraded Soldier performance or performance that fails to meet system requirements. By examining the performance data as well as analyzing questionnaires and interviews the testers should be able to narrow the causes of the performance deficiency. The analysis of the data becomes important as currently there is not instrumentation that will directly identify performance problems.

5. SPECIFIC TEST PROCEDURES. The selection of the test procedures are dependent on the item to be tested, the relevant HSI domains, the facilities/instrumentation available and the Program directed test data requirements. Specific procedures need to be consistent across the test runs if multiple runs are to take place. This TOP does not describe specific test procedures, which are covered in the specific HSI-domain TOPs.

5.1 Item Specific Test Procedures. The test item will prescribe which test procedures can and cannot be done. For instance, if the test was for glove acceptance then a finger dexterity test would be appropriate, but a run through the manpower/portability course would not be appropriate. The test procedures conducted on previous models of the same item could also be use and they would also serve as a basis of comparison of one model to the next.

5.2 MANPRINT Domain Specific Test Procedures. The MANPRINT domain to be assessed will prescribe which test procedures can be used. If a Soldier survivability assessment is to be accomplished then a manpower estimate or a habitability assessment is not needed for the test. Many of the MANPRINT-domain specific TOPs will outline which procedures are appropriate for each item and test item function. For example TOP 1-2-610 defines and classifies the test procedures for a human factors engineering domain test.

5.3. Facility/Instrumentation Specific Test Procedures. The use of the facility/instrumentation will prescribe which procedure can be used. For example, testers can collect operator mental workload data using a combination of physiological instrumentation, questionnaires and surveys. Some types of instrumentation might be facility dependent, while others can be used independently of a facility. Restrictions on money/time might also restrict the available choice for facilities/instrumentation.

When a test procedure is to be repeated on the item or between items, then it is essential to use the same facility/instrumentation to achieve repeatability of the results. This is important when the tester is tasked to compare two similar items (e.g., current production item and a legacy item).

5.4 Test & Evaluation Master Plan Specific Test Procedures. When the required test is part of an acquisition program, program documentation, such as the TEMP, will provide test guidance. If the documentation does not specify the test procedures to be used then it will specify the data (and associated tolerance levels) to be collected. The data required will prescribe the test procedures to be used. Certain data elements can only be produced by certain test procedures, making the selection dependent on the data needed.

APPENDIX A. SPECIFIC HSI T&E TOOLS

Typical HSI Test and Evaluation (T&E) Tools

Representative tools available to testers for measuring and documenting various aspects of Soldier performance during T&E are shown in Table 1. Note that no one tool alone is capable of providing data to sufficiently assess phenomena such as cognitive performance or SA. Thus, tool use must be tailored and applied for test events, as appropriate.

Table 1. T&E Tools

NASA Task Load Index (TLX) [Physical and mental workload]
Software Usability Measurement Inventory (SUMI)
Mission Awareness Rating Scale (MARS) [SA and SA-related workload]
Size, activity, location, unit, time, and equipment (SALUTE)-based survey[1]
Multiple Affect Adjective Check List – Revised (MAACL-R) [Psychological stress]
Cognitive Readiness Prediction Tool (CRPT)
Adaptive Character of Thought-Rational (ACT-R)
IMPRINT
Command, Control, and Communication Techniques for Reliable Assessment of Concept Execution (C3Trace)
SART (Situation Awareness Rating Technique)
Times to complete and errors associated with conducting critical battle command tasks
Secondary performance measures for workload
Situation Awareness Global Assessment Technique (SAGAT) [Primarily for use in simulators]
Demographic survey to include personal characteristics, training, and experience with automated systems
Six-degree-of-freedom motion table[2]
Test Incident Report
MANPRINT Problem Report
Detailed design checklists
Documented observations of mission tasks conducted in accordance with current and/or emerging tactics, techniques, and procedures (TTP)
Tailored questionnaires and interviews using scaled survey responses (e.g. Likert scales)
After Action Review (AAR) results
Detailed task checklists documenting Soldier behaviors (e.g. actions, verbalizations within a relevant context)
Mission and Means Framework (MMF)[3]
Physiological measurement instrumentation (heart rate and core temperature)
Methods to address Soldier exposure to whole-body vibration [ISO 2631-1]
Ground truth based on documented observations and sensor data
Human Computer Interface characteristics based on applicable standards and practices
Measures associated with personnel occupied areas: heating, cooling, lighting, acoustic noise (steady-state and impulse), and ventilation
Workspace accommodation for the range of Soldiers attired in appropriate mission

oriented protective postures
Speech intelligibility measurements at crew positions inside and outside platforms (e.g. modified rhyme test)

[1.] ARL-HRED used this survey in a summer 2006 FCS C4ISR exercise at Fort Dix to obtain SA data in an on-the-move environment.

[2]. At the Aberdeen Test Center (ATC) the Air/Ground Testbed is a distributed suite of tools that inserts the Soldier, vehicle, and/or other test component into an extreme simulated battlefield environment. Currently, this is achieved through a six-degree-of-freedom motion table vehicle dynamics simulator. The table provides laboratory control, which facilitates repeatability of defined scenarios, quick feedback from users, and Soldier in-the-loop testing of various design alternatives. Data generated using the motion table can augment data provided using surrogates and prototypes and will support modeling and simulation of Soldier performance.

[3.] MMF modeling and simulation efforts have demonstrated the ability to measure the mission impact of Soldier performance. The process can also identify the criticality of platform and Soldier actions to mission success with respect to TTP and Alternative Courses of Action (ACOA). This capability may provide insight into the tactics and ACOA to be investigated during testing.

APPENDIX B. ACRONYM LIST

AEC – Army Evaluation Center

AIS – automated information systems

AR – Department of the Army Regulation

ARL-HRED – U.S. Army Research Laboratory; Human Research and Engineering Department

AST – Army Test & Evaluation Command (ATEC) Systems Team

CB – Chemical & Biological

CDD – Capability Development Document

CG, DTC – Commanding General, Developmental Test Command

DA – Department of the Army

DoD – Department of Defense

DODD – Department of Defense Directive

DODI – Department of Defense Instruction

DTC – U.S. Army Developmental Test Command

DTP – Detailed Test Plan

EDP – Event Design Plan

HCI – Human Computer Interface

HE – Human Engineering

HFE – Human Factors Engineering

HHA – Health Hazard Assessments

HSI – Human Systems Integration

HUC - Human Use Committee

ICD – Initial Capabilities Document

ILS – Integrated Logistics Support

IMPRINT – Improved Performance Research Integration Tool

IWARS – Infantry Warrior Simulation

M&S – Modeling and Simulation

MANPRINT – Manpower and Personnel Integration

MMP – MANPRINT Management Plan

MOS – Military Occupation Specialty

MOUT – Military Operation on Urban Terrain

NASA TLX – National Air & Space Administration Task Load Index

NBC – Nuclear, Biological & Chemical

PAM - Pamphlet

PM – Program Manager

POC – Point of Contact

SA – System Assessments

SA – Situational Awareness

SART – Situational Awareness Rating Technique

SEP – System Evaluation Plan

SER – System evaluation Report

SME – Subject Matter Expert

SOMTE – Soldier, Operator, Maintainer, Test and Evaluation

SORD-PT – Soldier-Oriented Research and Development in Personnel and Training

STD - Standard

T&E – Test and Evaluation

T&E WIPT – Test and Evaluation Working Integrated Product Team

TEMP – Test and Evaluation Master Plan

TOP – Test Operationd Procedure

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Test Business Management Division (CSTE-DTC-TM-B), US Army Developmental Test Command, 314 Longs Corner Road Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: Transformation Division, CSTE-DTC-AT-TT-T; US Army Aberdeen Test Center, APG, MD 21005-5059. Additional copies are available from the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.